DOGM MINIERALS PROGRAM FILE COPY

8-



**CONSULTANTS GROUP** 

SALT LAKE CITY . RENO . CEDAR CITY

M/045/004 Level PECEIVED DOGM 4/23/90

CARR FORK RECLAMATION PROJECT
WATER QUALITY, WATERFALL EROSION,
REVEGETATION, PHOTO PLOTS

Prepared for

Anaconda Minerals Company 555 Seventeenth St. Denver, Colorado 80202

Prepared by

JBR Consultants Group 1952 E. Fort Union Blvd. Salt Lake City, Utah 84121

April 5, 1990

# Table of Contents

4 4 4

1.0	Intro	oduction	n .	•	•		•	•		•	
2.0	Surfa	ace Wate	er Monit	oring			3				
	2.1	Sampli	ng Locat	ions	and Pi	cocedi	ures				
			ring Res		•		•				
3.0	Wator	cfall E	rosion M	fonito	ring						
3.0			ring Loc			Proce	edure	s	ui i		
			ring Res		•		•	•		<b>7</b> • • •	
4.0	Povo	rotatio	n Monito	ring							
4.0			ring Res								
			Plots				100	j			
	1.2	1 2 1	Introdu	.ation	•	•		•		1 . As.	
						•	•	•			1
			Methods			•	:	•	•	•	•
		4.2.3	Plant (	cover	at Pho	oto Po	oints	•		•	•
				List	of T	ables					
2 2-1	Sar	mnle Po	ints and	Date	s Sami	hale				13. 13.34	
			Measure			•		k into			
					•	•		•			
4.1-1	50.	rr bu .		•	, ,	• • •	•	•			
4.2-	r PT	ant Com	position	n at P	hoto 1	Point	S	•		•	7
	#7 44679	#13 I - #15 - IS&R - #18 - #20 - #22 - #24 - Borro - #27 - Borro - #30 - Top o - Borro - Slag - Smelt - Borro - Smelt - #40 - Carr	rr Fork S&R Tail Borrow F Tailings Elton Tu IS&R Tai Borrow F IS&R Tai W Pit #8 IS&R Tai f Carr F W Pit #4 Pile er Site W Pit #1 er Site Smelter Fork Lar	lings Pit #9 S Area Innel Llings Pit #1 Llings Llings Clings Clings Cork T Backf Waste Site	Area de Area Area Area ailing	A C B B					
			Smelter	Sito	South	Δrm					
			w Pit #3		Doucii	ALI					
	#47 .	- POLTO	w FIL #3	,							

#### 1.0 Introduction

The objective of the reclamation monitoring plan has been to manage the revegetation project to insure the best possible chance of success. This required the monitoring of the contractor's work in seeding and planting the topsoiled areas, regularly checking progress of the plant growth and testing the soil for nutrient levels. Also the condition of the fences, channels, and other structures on the project were routinely monitored (1986 Reclamation Plan).

The second object of the monitoring was to sample the surface waters and channels to record changes in water quality in the Pine Canyon drainage area. The monitoring program extended for three years following completion of the reclamation with final measurements of plant growth and water quality occurring in late 1989. This report describes the monitoring results for water quality and waterfall erosion for the three year monitoring period to aid the reader in understanding water quality changes. The monitoring results are included for 1989 and a table is included for the photo plots for the full monitoring period. Refer to Monitoring Reports Years 1987 and 1988, Carr Fork Reclamation/Stabilization Project report by JBR Consultants Group, July 8, 1989, for a description of previous revegetation monitoring.

# 2.0 Surface Water Monitoring

### 2.1 Sampling Locations and Procedure

During the years 1987 through 1989, water samples were obtained from each of three locations on Pine Canyon Creek and a spring that emanates near the creek. These surface water sampling locations included: 1) SW-7, a spring which emanates from the base of the slag pile just west of SW-12; 2) SW-8, Pine Canyon Creek at the old diversion dam; 3) SW-9 Pine Canyon Creek at bridge upstream of old Elton Tunnel located approximately 1800 feet down-gradient of SW-8; and 4) SW-12, Pine Canyon Creek where the canyon begins adjacent to the slag pile. Each sampling site was sampled from 1986 through 1987 and semi-annually in 1988 and 1989.

The water samples were obtained and handled using standard EPA sampling and chain-of-custody methods. During each sampling period, the water at each sampling location was field analyzed for pH, conductivity, and temperature. The water samples were analyzed for drinking water parameters including dissolved metals. A summary of these analytical results is included in Appendix A. Total metals were analyzed in selected samples. Samples analyzed for dissolved metals were filtered through a 0.45 micron filter into a clean polyethylene plastic bottle. The metals samples were preserved with mitric acid and samples analyzed for nutrients were preserved with sulfuric acid. All sample bottles were then

labeled, sealed, and refrigerated until delivery to the lab. Sample laboratory analyses were performed by Chemtech of Salt Lake City, Utah, an EPA and State of Utah certified laboratory.

# 2.2 Monitoring Results

Water from Pine Canyon Creek was sampled eight times during the years 1987, 1988, and 1989. The goal was to sample each location during each sampling trip, however, some sites could not be sampled due to the lack of flow at the sampling station. One sampling station that could not be sampled during the full monitoring period was SW-7, the slag pile spring. This spring ceased to flow in approximately August 1987 and has not been observed flowing since that time. In addition, SW-9 was not flowing in January 1987 and in December 1989. A list of the dates and locations sampled are given in Table 2.2-1.

Table 2.2-1 Sample Points and Dates Sampled

Date	SW-7	SW-8	SW-9	SW-12
January 29, 1987	x	v	0	x
May 14, 1987	x	X	x	X
August 11, 1987	x	x	x	x
October 23, 1987	0	0	x	x
July 1, 1988	0	x	x	x
December 4, 1988	0	x	x	x
June 18, 1989	0	X	X	X
December 14, 1989	0	х	0	х

x - denotes sampling was performed

The analytical results of water quality samples collected during September 1986, 1987, 1988, and 1989 are contained in Appendix A. During the monitoring period, total dissolved solids (TDS) concentrations for Pine Canyon Creek generally ranged from 158 ppm to 433 ppm. The mean for all of the sites combined is 336 ppm. TDS concentrations from Pine Canyon Creek were all less than the Utah Drinking Water Standard of 500 ppm. The chemical parameters analyzed in this creek have not fluctuated appreciably since the beginning of the reclamation project.

TDS concentrations for SW-7, slag pile spring, were typically higher than TDS values in Pine Canyon Creek. TDS concentrations ranged from 510 ppm in January 1987 to 800 ppm in May 1987. When flowing, the spring discharge apparently increased the TDS concentrations in Pine Canyon Creek by approximately 40 ppm in SW-8. This effect has not been observed since spring flow ceased in 1987.

The major chemical constituents of Pine Canyon Creek waters include bicarbonate, calcium, chloride, magnesium, sodium, and

o - denotes sampling was not performed

sulfate. Although, some fluctuation in water quality has occurred since sampling began in 1985, all dissolved metals concentrations in Pine Canyon Creek are within Utah Drinking Water Standards. The largest fluctuations in the observed water quality parameters is discussed below for each sampling site.

Water quality fluctuations for the slag pile spring (SW-7) were noted in the period 1985 to August 1987. Below is a listing of those chemical parameters exhibiting increasing and decreasing trends during the monitoring period.

Decrease	Increase
Bicarbonate	Calcium
Boron	Chloride
Nickel	Copper
Silica	TSS
рН	Conductivity
	Fluoride
	Hardness
	Diss. Iron
	Sulfate
	TDS
	Zinc

Due to the relatively short period of time in which spring discharge occurred, no correlations may be made regarding the variations in water quality during this period.

Water samples obtained from the middle Pine Canyon Creek sampling site, SW-8, exhibited less fluctuation in chemical parameter concentration than did SW-7. There has been relatively no change in the concentrations of dissolved metals in SW-8 water since sampling began in 1985, although increases have been noticed in five other chemical parameters since 1986. The most notable increases occurred between June and December 1989. Chloride concentrations have increased from 27.2 ppm in 1986 to 96.0 ppm in Major increases occurred in mid 1987 and during the latter part of 1989. Also increasing in concentration from 1986 to the present is magnesium which changed from 29.2 ppm to 37.6 ppm, and increase of 29%. Calcium and sulfate concentrations doubled between June and December 1989 to concentrations of 88.4 and 116.0 ppm, respectively. Silica exhibited a threefold increase during the same period with 1989 concentrations of 24 ppm. The cause of these elevations in concentrations is unknown, though it is suspected that it could be the result of the reclamation of Pine Canyon, the source of flow in Pine Canyon Creek. The increases observed are not considered to be significant.

Water samples from SW-9 showed a continuous decrease in the concentrations of boron, nitrate, and silica from 1986 to December 1988. The concentrations of these parameters increased during the latter part of 1989. Boron and nitrate concentrations decreased

over 82 percent while silica concentrations decreased 21 percent during this period. Magnesium was the only chemical parameter from this location which increased steadily through 1988 (23.4 ppm to 40.1 ppm). Silica doubled in concentration during the latter half of 1989.

Many of the chemical parameters analyzed from site SW-12 exhibited minor fluctuations during the monitoring period. Fluctuations in concentration include alkalinity, bicarbonate, calcium, carbonate, chloride, nitrate, potassium, sodium, and sulfate. General increasing trends were observed in magnesium and silica concentrations between 1986 and 1989. Concentrations of magnesium increased approximately 47 percent and silica increased 75 percent during the monitoring period.

# 3.0 Waterfall Erosion Monitoring

# 3.1 Monitoring Location and Procedure

JBR has been monitoring the erosion of the Pine Canyon Creek waterfall to determine the present and estimate the future stability of this dynamic feature. The area upstream of the waterfall is a braided riparian zone, overgrown with vegetation and having a gentle gradient where it flows past the upper portion of the slag pile before dropping into a 60-foot deep gully eroded into alluvium. Pine Canyon Creek discharges over the falls precipice in two channels, referred to as the left and right branch, looking downgradient. The drop into the gully occurs in one jump. The channel in the gully bottom is maintained in the relatively soft alluvium where discharge continues toward the Great Salt Lake.

On January 21, 1987, a survey point was established approximately 100 feet upstream of the Pine Canyon Creek waterfall to monitor the potential for erosion of the waterfall. Monitoring consisted of measuring the relative distance from the left and right precipice of the falls to the survey control point. Erosion measurements were made from the top of the waterfall using an L-shaped, 17-foot long aluminum rod. The short arm of the measuring rod was hooked against the edge of the waterfall drop-off and the distance from the edge of the aluminum rod to the survey pin was measured with survey tape. Waterfall erosion was measured on the same schedule as the water samples.

### 3.2 Monitoring Results

A summary of the erosion measurements dates and distances between the left & right branches and the survey stake is given in Table 3.2-1.

Table 3.2-1 Waterfall Measurements

Date	Left Branch	Right Branch
January 28, 1987	103' 6"	100' 2"
May 14, 1987	99' 10"	99' 4"
August 10, 1987	99′ 7"	99' 6"
December 4, 1987	99' 10"*	96' 10"
July 1, 1988	96′ 4"	96' 10"
December 4, 1988	96' 4"	96' 10"
June 18, 1989	96′ 2"	96′ 5"*
December 14, 1989	96′ 2"	96′ 7"

<sup>\*</sup> Reported lots of vegetation in the way, possibly introducing inaccuracy in the measurement.

The results indicate that the ledge of slag which reinforces the lip of the waterfall is gradually eroding upstream by the undercutting action of the waterfall on the underlying gravel. Based upon these measurements, the left branch of the waterfall has eroded upstream approximately 7-feet 4-inches and the right branch has eroded approximately 3-feet 7-inches. The erosion of the right branch occurred primarily in 1987 with the left branch erosion primarily occurring in the first half of 1988. This would indicate that erosion from the waterfall continues to occur but at a limited rate. The rate of erosion appears to have stabilized over the course of the last several years.

# 4.0 Revegetation

# 4.1 Monitoring Results

# April 19, 1989

Weather: 75° high, 50° low; sunshine all day with occasional windy periods. The spring has been normal until last two weeks, when above normal temperatures has hastened the advent of early summer-like conditions.

Soil Moisture: The soils are dry in the upper layers. Recent digging in Pine Canyon has indicated little soil moisture in the upper 12" of soil. There is some soil moisture in the drainages and basins. All the catch basins, except one, are dry on the smelter site.

#### Vegetation:

The grasses are well established on the smelter site. Most current growth of the grasses are 8-12" in height. The Cicer's milvetch, sainfoin, sweetclover, alfalfa, and prairie clover are 6-10" high and robust. The globe mallow and primrose are just beginning growth. Bitterbrush, where it is found, has grown into a large rosette. Deer have browsed on the bitterbrush last

winter, and now are eating the new growth on the sweetclover.

The planted shrubs are doing well in the open unseeded areas, otherwise the few survivors have barely grown larger than the first years growth. This pattern of little growth is probably due to the dry conditions in the past drought year.

#### Borrow Pit #3:

The vegetation here is a very good stand of grasses and alfalfa. The alfalfa makes up about 10% of the total ground cover, higher than any other place at Carr Fork. The planted shrubs, especially the maples, are doing very well around the edges of the pit.

# Pine Canyon Landfill:

The plant cover on the landfill is still sparse, but improved over last year. The plants are widely spaced but very robust and large. The plant community consists of wheatgrasses, Cicer's milkvetch, yarrow, sweetclover (browsed by deer), bitterbrush, and mountain mahogany. The planted shrubs are represented by maples and groundcherry.

# June 6, 1989

The winter and spring had been very dry, but late rains in early June had brought some moisture to the site at the time of the visit. The forbs and the grasses were flowering at this time. The following plant communities were recorded on these sites:

### Borrow Pit #9

Agropyron cristatum
Agropyron spicatum
Medicago sativa
Petolstemon purpeneum
Artemisia arborantum - 4' tall
Elaeagneus angustifolia - few surviving plants

#### Borrow Pit #3

Agropyron elongatum Medicago sativa - robust plants Acer negundo - strong tall trees

#### August 16, 1989

The summer had been dry with no rain since early June during the last visit. The vegetation has thinned and some of the plants entered a dormant phase. The thinning of the seeded communities has allowed some limited invasion by forbs such as ragweed and sunflower. The following communities were noted at these sites:

IS&R Tailings
Agropyron cristatum
Kochia americana - big plants
Medicago sativa
Onobrychis viceafolia
Petalostemon purpeneum
Ceratoides lanata - few
Artemisia tridentata - few

Tailings Pond Dike

Agropyron cristatum - 95% of cover

Agropyron dasystachyum

Oryzopsis hymenoides - few plants

Medicago sativa

Onobrychis viceafolia

Petalostemon purpeneum

Melilotus alba

Atriplex cana - few big plants

Artemisia tridentata - few plants

Elaeagnus angustifolia - few poor plants

### November 3, 1989

The several bare areas within the seeded areas were checked on the ground and soil samples taken to help to determine why these small sites had not fully revegetated. A few sites could be explained by the fact the drill seeder became clogged in the wet soils and seed was not applied. However, these sites often had a delayed colonization by forbs and a few grasses. The other bare sites in question did not have any or very little colonization by plants. However, even on a few of these bare sites planted stock has survived and is flourishing.

It should be noted that these barren areas are associated with smelter site and occupy only 6.5 acres of the nearly 700 acres which have been successfully revegetated.

The pH associated with these areas was measured in the field and at the laboratory. Table 4.1-1 is a summary of the soil pH measurements.

Table 4.1-1 Soil pH

		Field	Lab	
Site	Acreage		Ho	Remarks
#1, not treated	-	4.3	4.3	outside of topsoiled area
#2, landfill	3.5	4.7	4.5	some planted shrub growth
#3, smelter	0.5	4.1	4.1	isolated clumps of grass
#4, smelter	0.5	4.0	3.9	bare hillside
#5, smelter	0.2	6.0	4.4	some colonization by forbs
#6, smelter	0.1	8.0	7.1	old waste pile site
#7, smelter	0.1	8.0	5.7	old waste pile site
#8, smelter	0.1	6.8	5.6	old RR tracks site
#9, smelter	1.5	7.3	5.9	top of Pine Canyon landfill
Total	6.5			

The occurrence of low pH levels may indicate higher than normal sulfate levels in some of the small bare sites. The procedure for securing topsoil substitute materials was to strip and bury the surface soils, which contained high sulfate, and to borrow the clean subsoil layers as topsoil materials. Apparently either small amounts of contaminated surface soils were included in the borrow materials and distributed as topsoil materials, or some pockets of subsoils materials containing high sulfate levels were included in the borrow and distributed as topsoil materials.

It is ARCO's intent to apply lime to the remaining 6.5 acres of acidic soils in 1990. The buffered areas will then be reseeded in the fall.

#### 4.2 Photo Plots

### 4.2.1 Introduction

This section contains all of the photo point data collected during the three years of monitoring at Carr Fork. It is brief summary of the photo sequences and the ocular estimates of the plant communities at the photo stations.



#### 4.2.2 Methods

The photo points were established at the time of seeding in the fall of 1986. The locations of the stations were based on one station per 20 acres in the larger reclamation treatment areas or at least one station for each of the smaller treatment areas. The forty five photo stations were visited each fall for three years (Year 1=1987, Year 2=1988, Year 3=1989) to take photos and to estimate by ocular reconnaissance the dominate plant species at the stations.

The photo stations were setup with a white background board and a small frame for a closeup photo. A second larger frame was included at the station as a reference for the distant photo. The closeup photo shows individual plant growth and changes while the distant photo shows the status of the changing plant communities.

At each photo station, an ocular reconnaissance was made to determine the dominant plants present in the immediate vicinity of the station. Each plant was then ranked according to its relative abundance in the plant community. Since the photo stations were established in an arbitrary manner prior to plant growth, the locations were considered random.

### 4.2.3 Plant Cover at Photo Stations

The forty five photo station series are displayed on two sheets, one for the closeup and one for the distant photo. The 1989 photos are difficult to compare due an early heavy snowfall in October that mashed the vegetation. Generally the photos show the establishment of a grass and legume community with adequate ground cover.

The ocular data for plant cover in Table 4.2-1 shows a trend towards simplification of the communities. This may be due to the drought conditions that prevailed from late 1987 through 1989, and favored the more drought resistant species such as crested wheatgrass.

The Valley Slope Salt Tolerant seed mix was used on the lower elevation areas and had no shrub species in the mix. The crested wheatgrass, green molly and small burnet were easily the dominant seeded species in these communities.

The Valley Slope seed mix, with shrub species, was used on the lower elevation sites. The crested wheatgrass is again the dominant omnipresent grass, the forbs are represented by a wide variety of legumes and a few non-legume species, the shrubs are dominated by four-wing saltbush and lesser frequency of winterfat. The native species of sunflower has become reestablished as part of the community.

The Smelter Ridge seed mix was used on the higher elevations of the project, and included seeded and planted shrubs. The thickspike wheatgrass and to a lesser extent the tall wheatgrass have become the dominant grasses in these communities. Alfalfa has come on strong in the latter part of the monitoring period to become the dominant forb in heavy grass stands. Yarrow is also present in many areas. The shrubs are four-wing saltbush (not planted or seeded) and antelope bitterbrush in selected areas. Many of the planted shrubs eventually succumbed to the prolonged drought.

Table 4.2-1 Plant Composition at Photo Points

<u>Ph</u>	oto Point	1987	Grasse:	5 1989	1987	Forbs 1988	1989	1987	Shrubs 1988
۷a	lley Slope	Seed M	ix. Sa	lt Toleran	+				
1	Carr Fork Tailings	Agcr Agsm	Agcr	Ager	Oeho -	Spgr2 Koam	Spgr <sup>2</sup>	_	<b>-</b>
	-	Brte Spcr		-	-	<del>-</del>	-	<u>-</u>	<del>-</del> -
2	Carr Fork	Ager	Ager	Agcr	Onvi	Koam	Sami	_	_
	Tailings	Sece	Agsp	Sece	_	Meal2 Pepu		-	<u>-</u>
3	Carr Fork	Agcr	Agcr	Agcr	-	Meal2	Sami	_	_
	Tailings	Sece	Agsp	-	_	Pepu	Meof	_	•••
	J	Agsp	Sece	_	_	Onvi	_	_	_
		Brte	-	-					
4	Carr Fork	Agcr	Agcr	Agcr	-	Koam	Koam		_
	Tailings	Sece	Agsp		-	Grsq	Hean <sup>3</sup>	-	-
		Agsm	Sece	. <b>-</b>					
		Sihy	-	-					
5	Carr Fork	Agcr	Agcr	Agcr	Orvi	Grsq	Sami	_	_
	Tailings	Brte	Agsp	_					
		Sece	Orspp	-					
		_	Sece	-					
	Carr Fork	Agcr	Agcr	Agcr	Orvi	Pepu	Sami	_	_
	Tailings	Brte	Agsp	-	Sami3		Orvi	-	-
			Agin	-	Pepu	Meal2	_	-	-
	IS&R	Agcr	Agcr	Agcr	Koam	Pepu	Koam	_	-
	Tailing	Sece	Sece	Sece					
	Area B	-	Agsp	Agsp					
	IS&R	Agcr	Agcr	Agcr	Koam	Meal2	Koam	_	-
	Tailings	Sece	Sece	-	-	Koam	Hean <sup>3</sup>	-	_
	Area B		Agsp	-					
	IS&R	Agcr		Agcr	Koam	Koam	Koam	-	-
	Tailings	Brte	Agsp	-	-	Grsq	-	-	-
10	IS&R	Agcr	Agcr	Agcr	0eho	Grsq	Amps	_	
	Tailings	Agin		_	_		Koam	_	-
	Area B								
11	IS&R	Agcr	Agcr	Agcr	Koam	Koam	Amps	_	_
	Tailings	Popr	Orspp	_	Meal2		Koam	-	-
	Area B		Agsp	-	Spgr2	-	-	-	-

Table 4.2-1 Plant Composition at Photo Points Con't.

<u>Pho</u>	oto Point	1987	Grasses	5 1989	1987	Forbs 1988	1989	1987	Shrubs 1988
12	IS&R Tailings Area B	Agcr Brte -	Agcr Agsp Orspp	Agcr - -	Spgr2 Meal2 Oeho	Meal2 - -	Spgr <sup>2</sup> - -	- - -	- - -
					Grsq	-	-		
13	IS&R Tailings Area B	Agcr Brte Agin	Agcr Agsp Agin	Agcr - -	Koam Orvi Saof4	Koam Meal2 Orvi	Koam Amps Saof <sup>4</sup>	-	<u>-</u> -
		-			Gapu Oeho	Pepu -	-	_	<del>-</del>
16	IS&R Tailings Area G	Agcr Sece Brte -	Agcr Sece Elju Agin	Agcr - - -	Koam Gapu	Koam Grsq	Koam Hean³	Atca Cela	-
19	IS&R Tailings Area A	Agcr Brte Sece Sihy	Agcr Agsp Agin Orspp	Agcr Agsp -	Gapu Oeho Saof4	Grsq - - -	Amps - -	Atca - - -	- - -
20	IS&R Tailings Area A	* * *	Agcr Agin Sece	Agcr - -	*	Koam Grsq	Sami -	<u>-</u>	<del>-</del>
23	IS&R Tailings Area C	Agcr Agin	Agcr Agsp	Agcr -	Orvi Koam Spgr2	Pepu Koam -	Sami Hean³ -	- - -	- - -
24	IS&R Tailings Area C	Agcr Popr Brte	Agcr Agsp Orspp	Agcr - -	Koam Oeho Pepu	Koam - -	Koam Hean³ Sami	- - -	<del>-</del> 
26	IS&R Tailings Area B	Agcr Agsm	Agcr Agsp Popr	Agcr - -	Spgr2 Koam -	Koam Pepu -	Koam Orvi Hean³	- -	- - -
27	IS&R Tailings Area B	Agcr Brte Sece	Agcr Agsp Elju Agda	Agcr - - -	Koam -	Spgr2	Koam Hean³	<del>-</del> -	<u>-</u> -
29	IS&R Tailings Area B	* * *	Agcr Agel3 Elju	* * *	*	Pepu Grsq	*	-	-

Table 4.2-1 Plant Composition at Photo Points Con't.

Photo Point	1987	Grasses	5 1989		1987	Forbs 1988	1989	1987	Shrubs 1988
				•					
30 IS&R Tailings Area B	* * *	Agcr Brte Agsp	Agcr Agsp		* * *	Koam - -	- - -	- - -	- - -
37 Waste Material	Agsm Agcr - -	Agda Agcr Agsm Agin	Agda Agcr -		<del>-</del>	Orvi Spgr2	Sami -	<u>-</u>	<del>-</del> -
Valley Slope	Seed M	<u>ix</u>							
14 Borrow Pit #9	Agcr Agsp - -	Agcr Stco4 Agsp Sihy	Agcr - -		- - -	Meal2 Pepu Oeho	Hean³ Amps -	Arab Cela -	Atca Cela -
15 Borrow Pit #9	Agcr Spcr Sihy	Agcr Stco4 -	Agcr - -		Gapu Saof4 Pepu Mesa Spgr2	Mesa Pepu Meal2 Gapu	Mesa Pepu - -	Atca Cela - -	Atca Cela Rhspp - -
17 Elton Tunnel	Agcr Sece	Agcr Sece	Agcr -		Meal2 Orvi	Koam Grsq	Koam Hean³	Arab Elan Fapa	Chna - -
18 Elton Tunnel	Agcr Sece	Agcr Sece	Agcr -		<del>-</del>	Koam Grsq	Koam Hean³	Fapa Elan	Chna -
21 Borrow Pit #10	Agcr Agsp - -	Agcr Sece Agin Orspp	Agcr - - -		Meal2 Orvi - -	Meal2 Oeho Orvi Pepu Asch2	Meal <sup>2</sup> Pepu	Cela Atca Elan	Cela Atca Elan Putr
22 Borrow Pit #10	Agcr Agsp	Agcr Stco4	Agcr		Meal2 Pepu	Meal2	Pepu -	Cela	-
25 Borrow Pit #8	Agcr Agin Agsm Sece	Agcr Agsp Sece	Agcr Agsp - -		Orvi Gapu Meal2	Pepu Meal2 -	Sami Mesa -	Cela Atca	Atca Cela

Tal	ole 4.2-1		<b>Compo</b> Grasse		at	Photo 1	Points Forbs	Con't.		Shrubs
Pho	oto Point	1987	1988	1989		1987	1988	1989	1987	1988
28	Borrow Pit #7	Agcr Agda Agsp Agsm	Agcr Agsp - -	Agcr Agsp -		Orvi Pepu -	Spgr2 Pepu -	Pepu Sami -	Atca Cela -	Atca Cela Putr
31	Top of Carr Fork Dam	Agcr Agsm	Ager Agsp Sper	Agcr Agsp -		Meal2 Orvi -	Pepu - -	Sami - -	Cela Atca -	Atca Cela Artr
Sme	elter Ridge	e Seed	<u>Mix</u>							
32	Borrow Pit #4	Agsm Sece -	Agda Agsm Elju	Agda Elju -		Hean3 Acmil	Grsq -	<del>-</del>	-	-
33	Slag Pile	Agsm Agda	Agda Agsm	<u>-</u>		-	-		Cele	
34	Backfill	Agda Agsm Agda	Elju Agsp -	Agda Elju Popr		-	-	-	Atca	Atca
35	Borrow Pit #1		-	-		Oeho	<b>-</b> .	Sakat	Atca	-
36	Borrow Pit #2	Agda Agsp -	Agda Elju Agsp	Agel³ Agda Elju		Sakat Gapu Orvi	Acmil Mesa -	Acmil - -	<u>-</u>	Atca Putr
38	Smelter Area	Agsm Agda Agsp -	Agsp Agda Agcr Elju	Agda Agel <sup>3</sup> Popr		Acmil -	Grsq Mesa	Meal <sup>2</sup>	Atca	-
39	Smelter Area	Agcr Agda Agsp	Agsp Agda Elju	Agda Agsp Agcr		Mesa Asci4	Mesa -	Mesa -	Atca	Atca
40	Smelter Area	Agda Agsp - -	Agsp Agcr Elju Agda	Agel <sup>3</sup> Agsm Agda -		Mesa Acmil Oeho	Acmil Pepu -	Mesa - -	Atca	-
41	Carr Fork Landfill	Bar	e grou	nd, no	see	eding in	n this	area		

Table 4.2-1 Plant Composition at Photo Points Con't.

Photo Point	1987	Grasse: 1988	s 1989	Fort 1987 1988		1987	Shrubs 1988
42 Smelter Area	Agda Agsp	Agsp Agda Elju	Brte Agsp	Acmil -	-	Atca	<b>***</b>
43 Smelter Area South	Agda - -	Agda Popr Agel3	Agel <sup>3</sup> Agda -	Hean3 Hean Mesa - Spgr2 - Acmil - Gapu - Sakat -	3 Spgr <sup>2</sup> Hean <sup>3</sup>	- - -	- - -
44 Smelter Area South	Agda Agsm Agsp	Agda Elju Agsp	Agda Agcr Elju	Meal2 Spgr Asci4 Meal Koam Asci	L2 -	- - -	- - -
45 Borrow Pit #3	*	*	Agel <sup>3</sup>	* * * * * *	Mesa Asci <sup>4</sup> Acmil	*	*

<sup>\*</sup> station was not visited, no recordings of plant composition

#### Grasses

Agcr = Agropyron cristatum, crested wheatgrass

Agda = Agropyron dasystachyum, thickspike wheatgrass

Agel3 = Agropyron elongatum, tall wheatgrass

Agin = Agropyron inerme, beardless wheatgrass

Agsm = Agropyron smithii, western wheatgrass

Agsp = Agropyron spicatum, bluebunch wheatgrass

Brte = Bromus tectorum, cheatgrass

Elju = Elymus junceus, Russian wildrye

Orspp = Oryopsis species, ricegrass

Popr = Poa pratensis, bluegrass

Sece = Secale cereale, rye

Sihy = Sitanion hystrix, squirreltail grass

Spcr = Sporobolus cryptandrus, sand dropseed

Stco4 = Stipa comata, needle and thread grass

### Table 4.2-1 Plant Composition at Photo Points Con't.

# **Forbs**

Acmil = Achillea millefolium, western yarrow Asci4 = Astragalus ciceri, Cicer's milkvetch

Asch2 = Aster chilensis, Pacific aster Gapu = Gaillardia puchella, firewheel Grsq = Grindella squarosa, gumweed Hean3. Helianthus annuus, sunflower Koam = Kochia americana, green molly

Meal2 = Melilotus alba, white sweetclover

Mesa = Medicago sativa, alfalfa

Oeho = Oenothera hookeri, Hooker's primrose

Onvi = Onobrychis vicaefolia, sainfoin

Pepu = Petalostemon purpeneum

Sakat = Salsola kali, Russian thistle
Sami = Sanguisorba minor, small burnet
Saof4 = Saponaria officinalis, bouncing bet

Spgr2 = Sphaeralcea grossulariaefolia, gooseberry globemallow

#### Shrubs

Arab = Artemisia arbrotanum, oldman wormwood

Artr = Artemisia tridentata, sagebrush

Atca = Atriplex canescens, four-wing saltbush Cele = Cercocarpus ledifolius, curleaf mahogany

Cela = Ceratoides lanata, winterfat

Chna = Chrysothamnus viscidiflorus, rubber rabbitbrush

Elan = Eleagnus angustifolia, Russian olive

Fapa = Fallugia paradoxa, Apache plume Putr = Purshia tridentata, bitterbrush

Rhspp = Rhus species, sumac

	SW-7	SW-7	SW-7	SW-7
	1-29-87	5-14-87	8-11-87	5-14-87
	Diss	Diss	Diss	Tot
Alkalinity	168		139	188
Aluminum	0	0.1	0.01	0.1
Ammonia	0.1		0.12	0.26
Arsenic	0.01	0.01	0.01	0.01
Barium	0.048	0.075	0.01	0.075
Bicarbonate	205		169	229
Boron	0.21		0.12	0.35
Cadmium	0.01	0.01	0.015	0.012
Calcium	73.1	89.4	103	90.2
Carbonate	0		0	0
Chloride	30.3		36.5	41
Chromium (hex)	0.01	0.01	0.01	0.01
Chromium (tot)	0.01	0.01	0.01	0.01
Molybdenum	0.01	0.01	0.01	0.02
TSS	1.2		1.6	3.2
Conductivity	751		971	1080
Copper	0.032	0.033	0.048	0.033
Fluoride	1.07		2.01	1.36
Hardness	314		393	446
Hydroxide	0		0	0
Iron (diss)	0.032	0.055	0.26	
Iron (tot)	0.16			0.075
Lead	0.01	0.01	0.01	0.01
Magnesium	35.2			55.6
Manganese	0.012	0.018	0.12	0.018
Mercury	0.0002	0.0002	0.00023	0.0002
Nickel	0.01	0.018	0.06	0.018
Nitrate	1.07		1.02	1.03
Nitrite	0.005		0.005	0.005
Phosphate	0.024			0.03
Potassium	17.5	26	25.8	26.2
Selenium	0.002	0.002	0.002	0.002
Silica	7.1		6.61	7.7
Silver	0.01	0.01	0.01	0.01
Sodium	30.1	65.8	48.2	65.8
Sulfate	169		352	413
TDS	510		763	800
Turbidity	0		3.4	0.48
Zinc	1.58	1.85	8.8	2.72
PH	8.32		7.88	7.74
Cations			8.18	12.63
Anions			11.25	13.6

	SW-8	SW-8	SW-8	SW-8	SW-8	SW-8	SW-8	SW-8	SW-8	SW-8
	9-18-86	1-29-87	5-14-87	8-1-87	7-1-88	12-4-88	6-18-89	12-14-89	9-18-86	5-14-87
	Diss	Diss	Diss	Diss	Diss	Diss	Diss	Diss	Tot	Tot
Alkalinity	162	179		180	157	171	103	167		213
Aluminum		0	0.1	0.01						4.18
Ammonia	0.1	0.19		0.1	0.1	0.2	0.2	0.82		0.42
Arsenic	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.022
Barium	0.01	0.06	0.079	0.01	0.26	0.01	0.03	0.01	0.019	0.115
Bicarbonate	186	218		198	169	208	116	204		250
Boron	0.18	0.02		0.18	0.037		0.18	0.226		0.15
Cadmium	0.01		0.01	0.01	0.01		0.01	0.01	0.01	0.01
Calcium	49.2		56.2		47.2		41.2			58.5
Carbonate	9.7	0		10.7	11		4.6	0		0
Chloride	27.2			27.4	42.8	63	30	96		40
Chromium (hex)	0		0.01	0.01	0.01	0.01	0.01	0.01		0.01
Chromium (tot)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.032	0.01
Molybdenum	0.01	0.01	0.01	0.01					0.01	0.01
TSS	1170	1		2.8						970
Conductivity	509	527		541	542		418	580		590
Copper	0.015	0.018	0.01	0.01	0.01	0.01	0.028	0.01	2.95	
Fluoride	0.18	0.08		0.1	0.23	0.3	0.26	0.32		0.18
Hardness	234	247		257	247	251	186	389		272
Hydroxide	0	_		0	0	0	_	0		0
Iron (diss)	0.46	0.18	0.05	0.3	0.018	0.01	0.055	0.01		
Iron (tot)	0				0.113				33	
Lead	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.72	
Magnesium	29.2	29.1			33.6	37.6	18.1	37.6		37.9
Manganese	0.012	0.012	0.015	0.01	0.01	0.01	0.01	0.01	1.07	0.44
Mercury Nickel	0.0002	0.0002	0.0002	0.0002	0.0002		0.0002	0.0002	0.0002	
	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.025	0.01
Nitrate	1.67	1.39		0.86	2.78	0.64	0.998	1.02		1.92
Nitrite	0.025	0.029		0.005	0.008	0.005	0.006	0.005		0.012
Phosphate Potassium	0.05 3.4	0.033		,	0.01	0.01	0.012	0.01		0.015
Selenium	0.002	1.6 0.002	1.3	1	1.4	3.2	4.2	1.7	0 000	1.3
Silica	0.002		0.0022	0.002 7.05	0.002 7.3	0.002 6	0.002 7.2	0.002 24	0.002	0.004 10.4
Silver	0.01	0.01	0.01		0.01	0.01	0.01	0.01	0.01	
Sodium	8.22		25.4	20.5						25.5
Sulfate	61		25.4	81						55
TDS	343	343		380			244	195		287
Turbidity	0			1.4			0.78			28
Zinc	0.035									
PH	8.45		0.002	8.55				8.01		7.99
Cations	0.15	0.27		3.17				0.01		7.21
Anions				6.08						6.58
Acidity	0			0.00	V.11	· · ·				3.55
Cyanide	0.002									
Sulfide	0.1									
TOC	18.8									
Oil and Grease	0.5									

Carr Fork Water Quality Analyses Concentrations in ppm

	SW-9	SW-9	SW-9	SW-9	SW-9	SW-9	SW-9	SW-9	SW-9
	9-18-86	5-14-87	8-11-87	10-23-87	7-1-88	12-4-88	6-18-89	9-18-86	5-14-87
	Diss	Diss	Dies	Diss	Diss	Diss	Diss	<b>Tot</b>	Tot
Alkalinity	137		182	182	140	189	142	``	238
Aluminum		0.1	0.01						7.55
Ammonia	0.1		0.1	0.12	0.1	0.2	0.2		0.26
Arsenic	0.01	0.01	0.01	0.013	0.01	0.01	0.01	0.01	0.04
Barium	0.01	0.01	0.01	0.045	0.18	0.01	0.038	0.045	0.085
Bicarbonate	167		202	220	155	230	171		290
Boron	0.26		0.15	0.041	0.03		0.22		0.14
Cadmium	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.038	0.01
Calcium	52.5	56.5	44.2	66.8	41.2	52.9	40.8		58.4
Carbonate	0		10	1.2	7.6	0	1.2		0
Chloride	23.6		27.3	58.6	39.5	84	29.8		39
Chromium (hex)	0	0.01	0.01	0.01	0.01	0.01	0.01		0.01
Chromium (tot)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.01
Molybdenum	0.01	0.01	0.01	0.01				0.11	0.01
TSS	1360		2.8						1510
Conductivity	0.025		552	514	512	603	485		584
Copper	0.78	0.01	0.01	0.01	0.01	0.01	0.043	5.08	0.22
Fluoride	260		0.31	0.1	0.17	0.41	0.26		0.31
Hardness	0		<b>25</b> 2	253	230	296	211		267
Hydroxide	0.67		0	0	0	0	0		0
Iron (diss)	0	0.038	0.32	0.01	0.01	0.02	0.015	_	7.1
Iron (tot)				0.078	0.03			105	
Lead	0.022	0.01	0.01	0.01	0.01	0.01	0.01	3.36	0.01
Magnesium	23.4			31.8	32.9	40.1	25.6		38.2
Manganese	0.018	0.02	0.01	0.01	0.01	0.01	0.01	1.23	0.64
Mercury	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Nickel Nitrate	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.095	0.01
Nitrate Nitrite	2.05		0.89	0.77	0.96	0.36	0.452		1.9
Phosphate	0.037 0.02		0.005	0.005	0.009	0.0083	0.005		0.026
Potassium	6.5		0.0	0.01	0.01	0.01	0.016		0.017
Selenium	0.002	1.3 0.002	0.8 0.002	1.3 0.002	1.2 0.002	5.9 0.002	3.5 0.002	0.003	1.3 0.0056
Silica	0.002	0.002	7.11	7.1	6.3	5.6	10.3	0.003	10.5
Silver	0.01	0.01	0.01	0.018	0.01	0.01	0.01	0.01	0.01
Sodium	8.18	25.1	20.6	16.7	19.2	30.2		0.01	25.2
Sulfate	90	2311	61	53	84	64	48		55
TDS	353		400	351	342	393	308		392
Turbidity	0		1.3	0.72	0.7				45
Zinc	0.052		0.01	0.048	0.01	0.01	0.023	1.99	0.42
pН	8.25		8.5	8.37	8.6	7.74	8		8.32
Cations			3.14	6.72	5.63	7.4	•		7.21
Anions			5.72	6.42					7.04
Acidity	0		_	0					
Cyanide	0.004								
Sulfide	0.1								
TOC	27.8								
Oil and Grease	2.62								

	SW-12	SW-12	SW-12	SW-12	SW-12	SW-12	SW-12	SW-12	SW-12	SW-12	SW-12
	9-18-86	1-29-87	5-14-87	8-11-87	10-23-87	7-1-88	12-4-88	6-18-89	12-14-89	9-18-86	5-14-87
	Diss	Diss	Diss	Diss	Diss	Diss	Diss	Diss	Diss	Tot	Tot
Alkalinity	159	183		187	183	167	165	157	162		248
Aluminum		0	0.1	0.01							2.3
Ammonia	0.1	0.18		0.1	0.1	0.26	0.2	0.2	0.3		0.28
Arsenic	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.012	0.013
Barium	0.01	0.082	0.01	0.01	0.055	0.33	0.01	0.01	0.01	0.012	0.145
Bicarbonate	189	210		213	217	185	197	189	198		303
Boron	0.2	0.03		0.22	0.028	0.024		0.2	0.208		0.13
Cadmium	0.01			0.01	0.01			0.01		0.01	0.01
Calcium	48.5	52.2	50.7	45.4	69.2	52.3	44.8	52.5	72.1		58.9
Carbonate	3.3			7.2	3.1			1			0
Chloride	26.1			26.4	24.4	80.3	51	32.8			38
Chromium (hex)	0			0.01	0.01	0.01	0.01	0.01			0.01
Chromium (tot)	0.01		0.01	0.01	0.01	-	0.01	0.01	0.01	0.015	0.01
Molybdenum	0.01	0.01	0.01	0.01	0.01					0.01	0.01
TSS	680			4.4							500
Conductivity	502			542	519			545			584
Copper	0.032			0.01	0.01	0.01	0.01	0.048		0.185	0.068
Fluoride	0.17			0.02	0.1			0.25			0.26
Hardness	237			252	255			249			270
Hydroxide	0	-		0	0	0	0	0			0
Iron (diss)	2.5			0.3	0.081		0.01	0.17	0.01		
Iron (tot)	0				0.28	0.505				11.2	3.58
Lead	0.16		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.48	0.01
Magnesium	25.3		0.022		31.8	32.8	30.8	39.7	37.2		41
Manganese	0.09			0.01	0.01	0.02		0.01	0.01	0.46	0.25
Mercury	0.0002		0.0002	0.0002	0.0002			0.0002		0.0002	0.0002
Nickel	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01
Nitrate	1.86			0.99	0.46			1.9			1.78
Nitrite	0.011			0.005	0.005		0.005	0.005			0.026
Phosphate	0.05				0.01	0.01	0.01	0.015			0.03
Potassium	2.7				1.7		6.9	2.6			2
Selenium	0.002		0.002		0.0022			0.002		0.002	0.0023
Silica	0			8.15	8			17.3			9.6
Silver	0.01				0.012			0.01		0.01	
Sodium	8.16				16.5						25.2
Sulfate	64			75	104			125			55
TDS	344			400	325			402			396
Turbidity	0			2.1	0.87			0.42			20
Zinc	0.065				0.095			0.023			
PH Cariana	8.41	8.5		8.47	8.33				8.24		8.92
Cations				3.24	6.83						7.48
Anions	_			6.06	6.52	7.26	5.96				7.22
Acidity	0			0							
Cyanide	0.006										
Sulfide	0.1										
TOC	21.2										
Oil and Grease	1.26										